Pre-Injector Overview & Goals

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17 Mar 2010

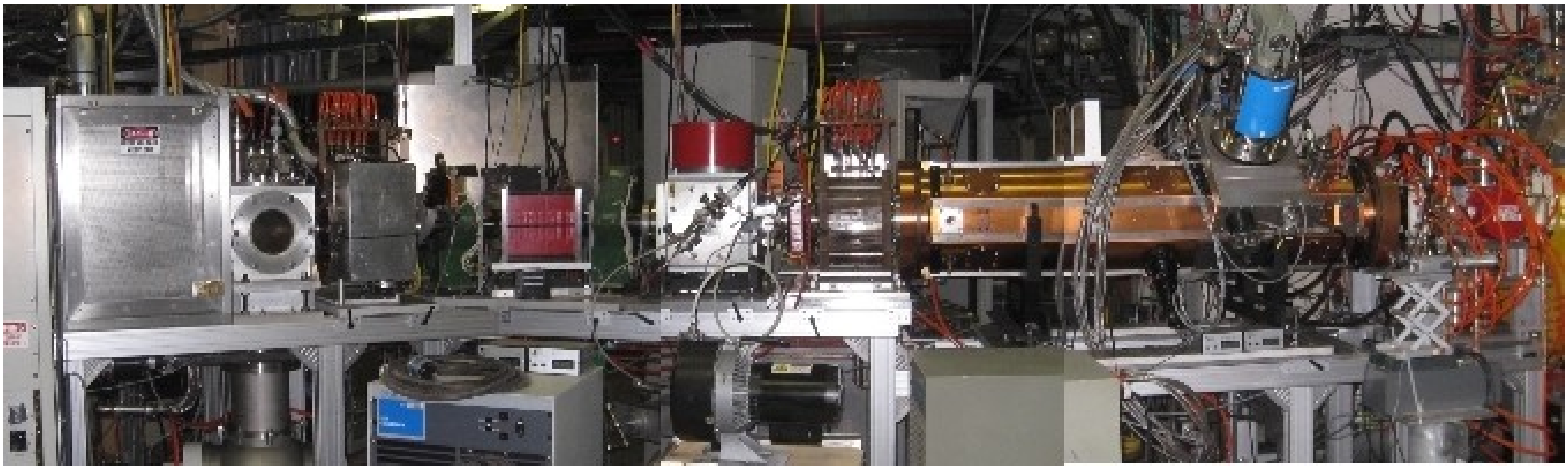
Overview

- How the new pre-injector looks like
  - Round Source
  - LEBT
  - RFQ
  - MEBT
- Work that is ongoing
  - Round source (Bollinger)
  - Chopper (Bollinger, Tan, Lackey, Markarov)
  - Solenoids, quads (Markarov, Kashikin, Velev)
  - RFQ (outside vendor, req is approved, being bought)
  - Buncher (not bought yet, hopefully will piggback on BNL order)
  - Steerers (copy, modify BNL design)

Why Magnetron Source+RFQ?

- Proven technology
  - BNL retired Cockcroft Waltons in the 1989(!).
    - Has been running reliably with ONE source + RFQ since that time
    - Beam quality and losses are better than Cockcroft Walton (DC versus bunched beam at the start of DTL 1)
  - Magnetron source
    - Dimpled (or round) magnetron source can produce 100mA of H- for 500 us. Our requirement is ~50-60mA for 100 us. Can run for > 6 months!
    - Local expertise with slit magnetron source.
    - Leverage HINS programme.

Picture of BNL Pre-Injector

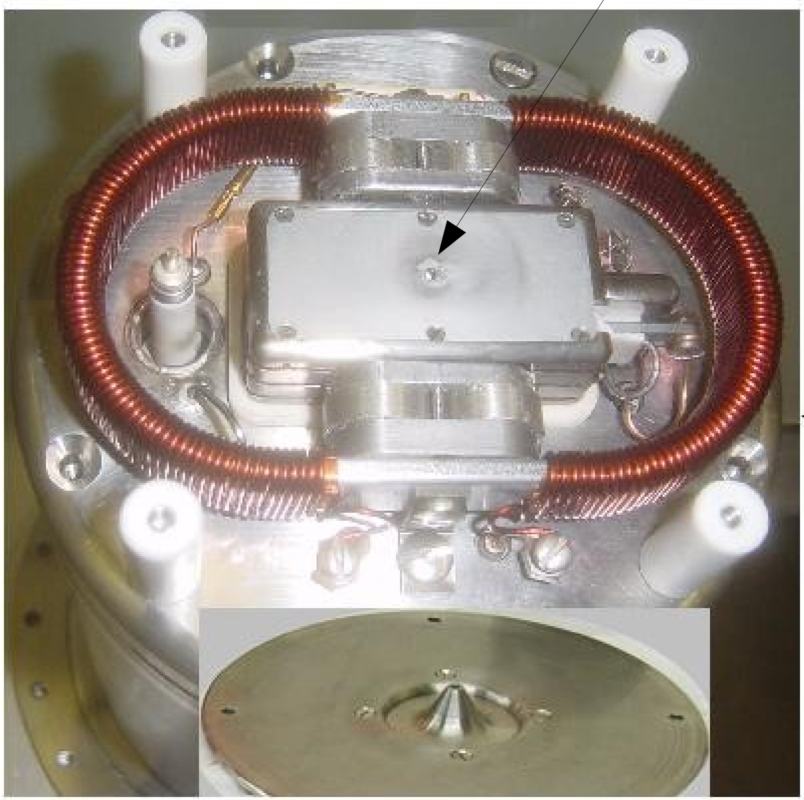


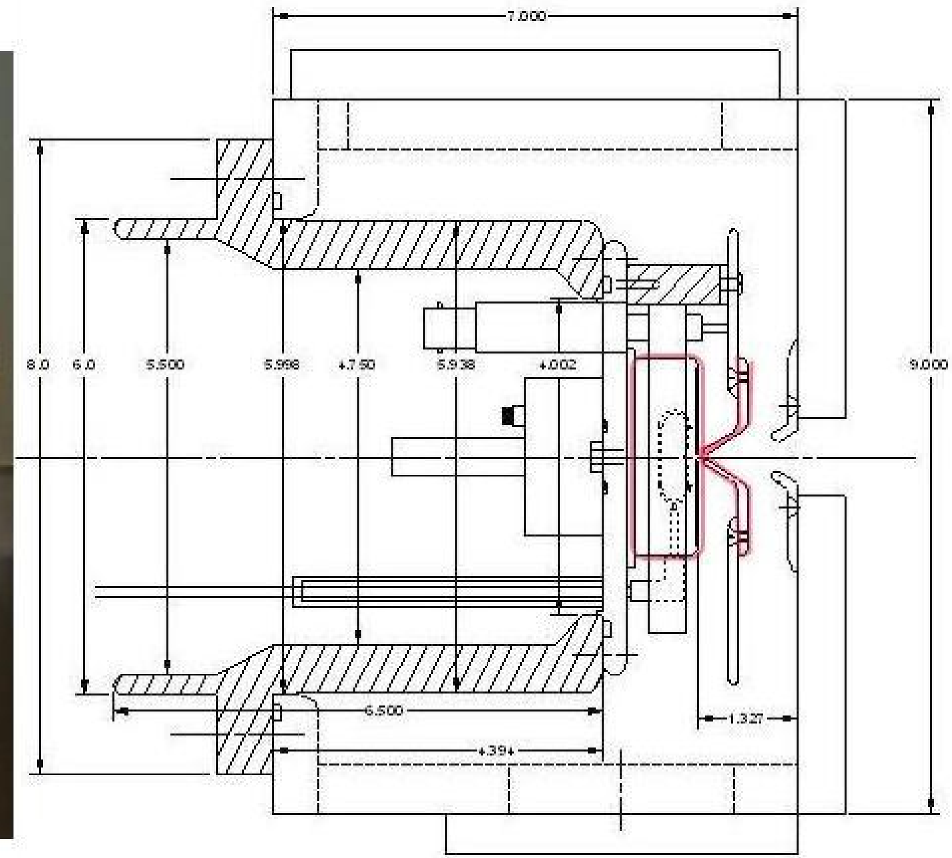
Length of our pre-injector will be about 12-15ft

Source

Round Source

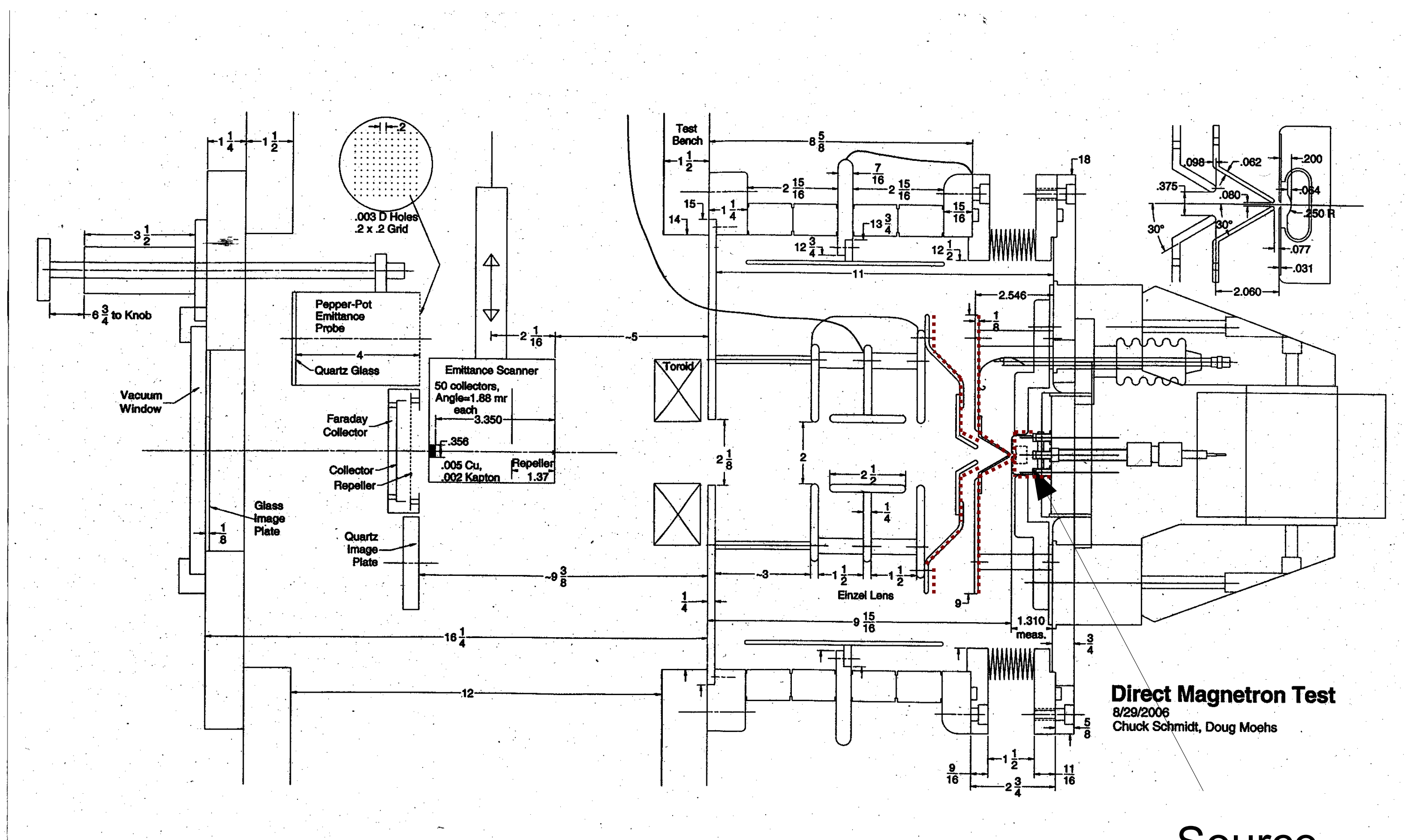
Dimple





HINS round source very similar to BNL source. Presently making one. Goal: to show 90-100mA for 100 us (c.f. BNL 100mA for 500 us)

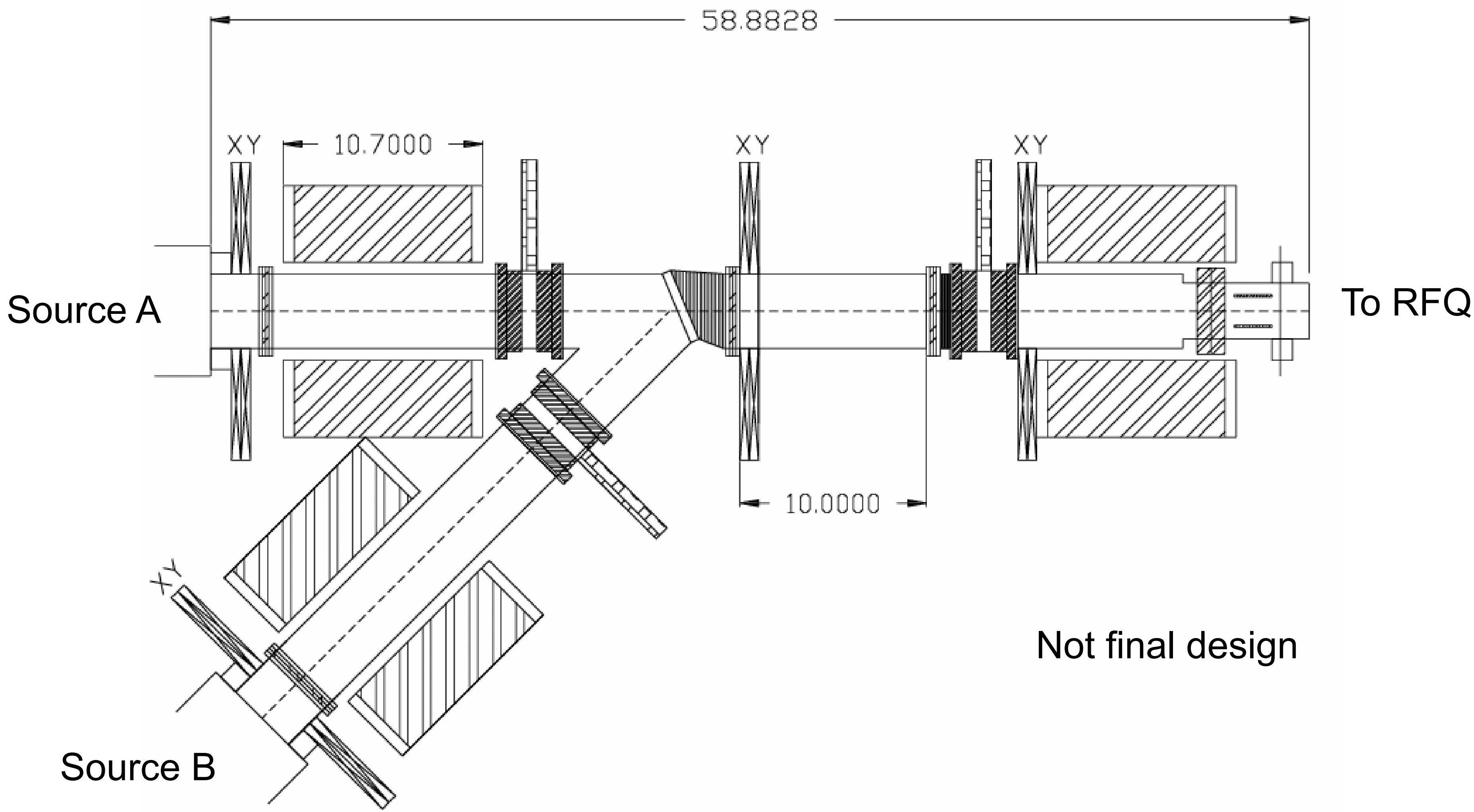
H- Source Test Stand



Source

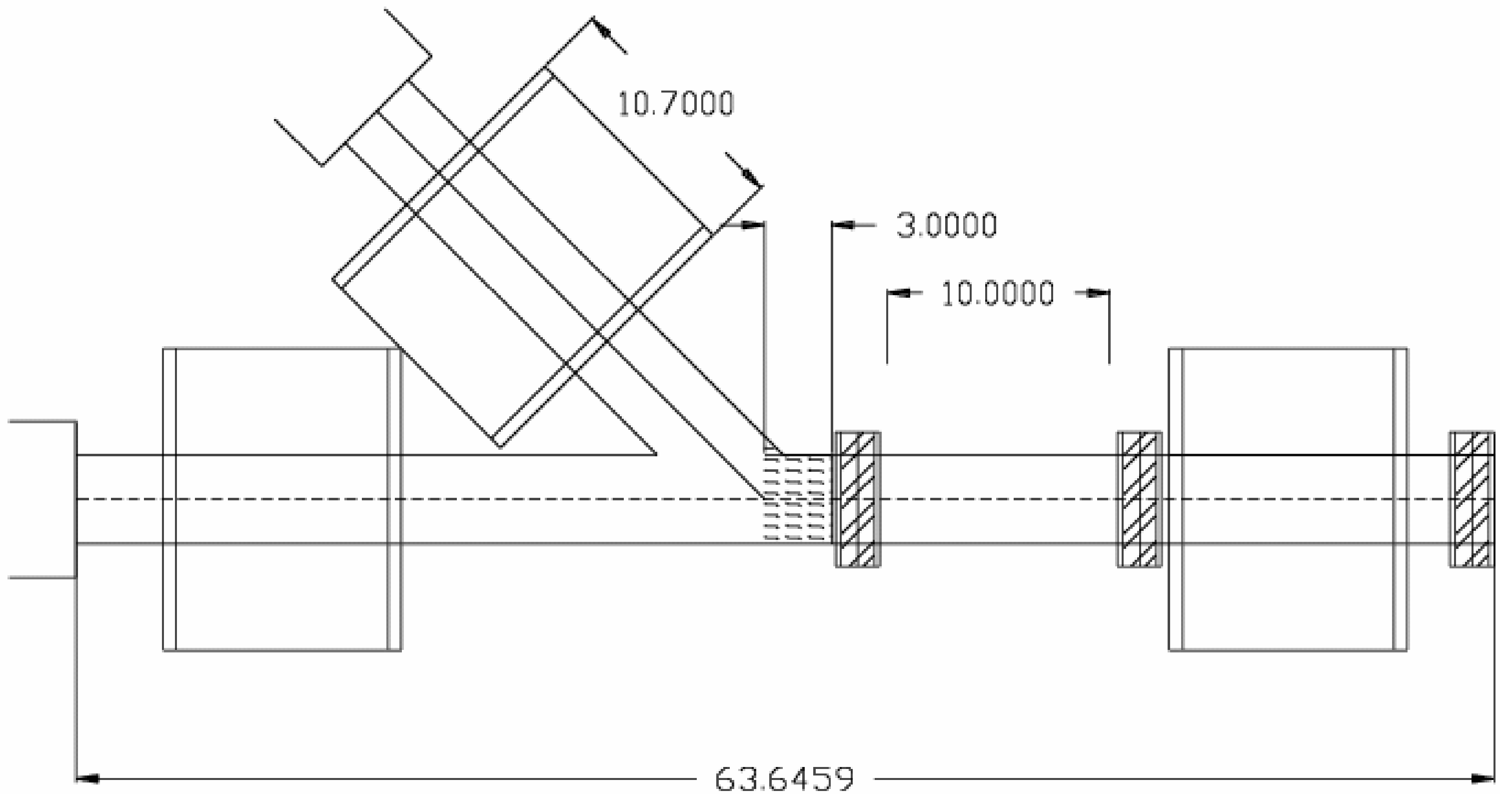
LEBT

LEBT

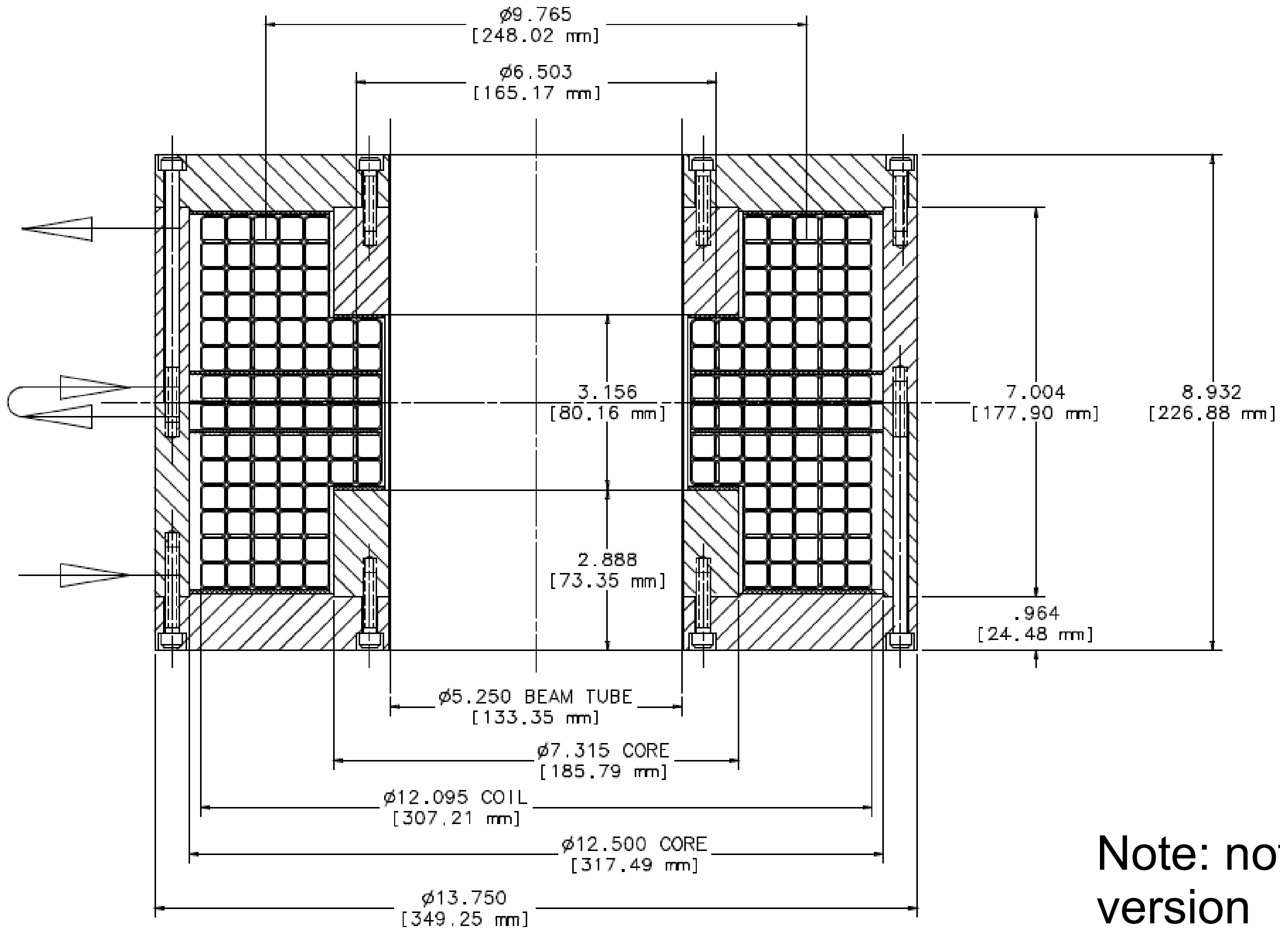


Not final design

Secondary Configuration



Preliminary Solenoid Design



VARIANT #3

2 IDENTICAL COILS CONNECTED IN SERIAL
TOTAL NUMNER OF TURNS – 82
NEEDED CONDUCTOT LENGTH – 2 X 105 FT

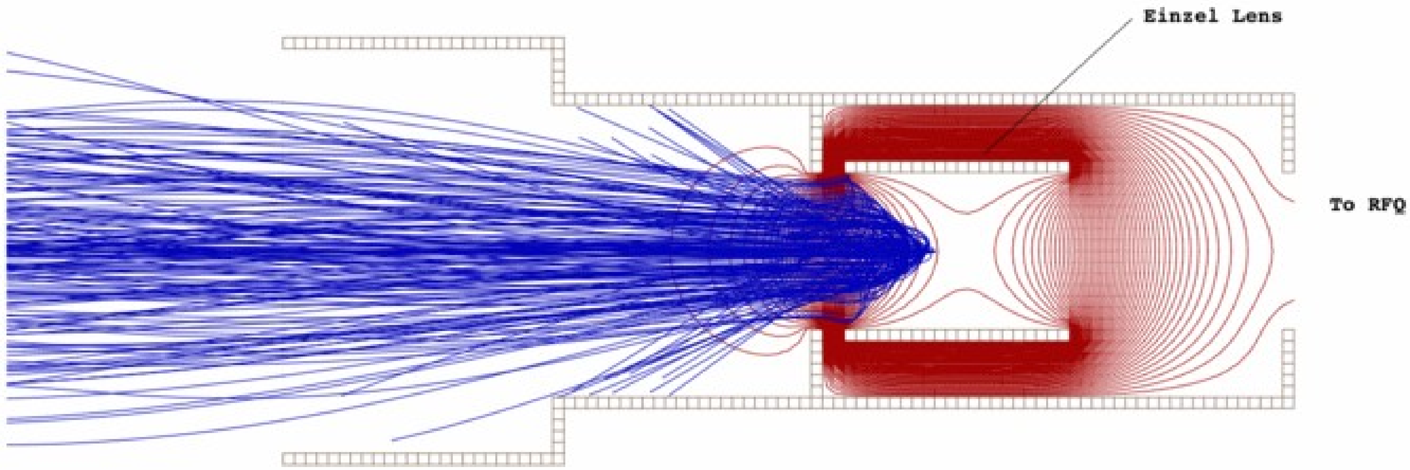
Note: not latest version

Has been designed. Going ahead with prototype. 4.75” bore

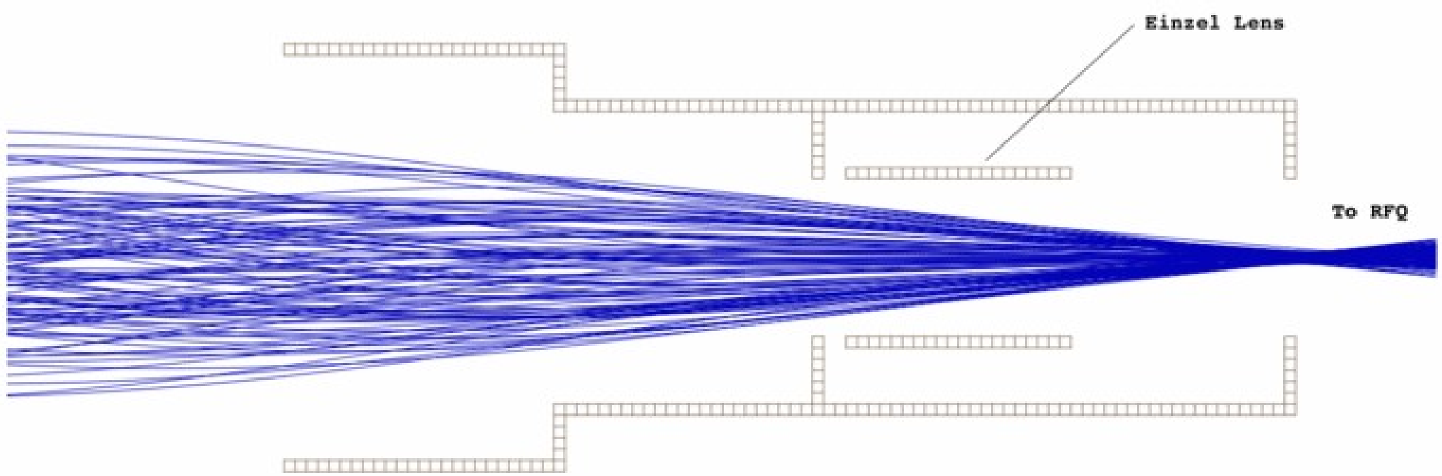
Chopper

Chopper

- Chopper is critical for the pre-injector
  - Electrostatic is usually bad
    - Want to keep H- beam neutralized with Xe+ ions.
  - Our solution (Cut 40us rise time to < 1us?)
    - Use Einzel lens just before RFQ to keep de-neutralization region as small as possible.
    - H- beam is focused near this point, so deneutralization not effective anyway. (Guess)
- Tests with Einzel lens powered to > 36kV has already been done. Looks good!
  - Reverse polarity, pulse it
  - Shoot H- at it
  - Add Xe gas

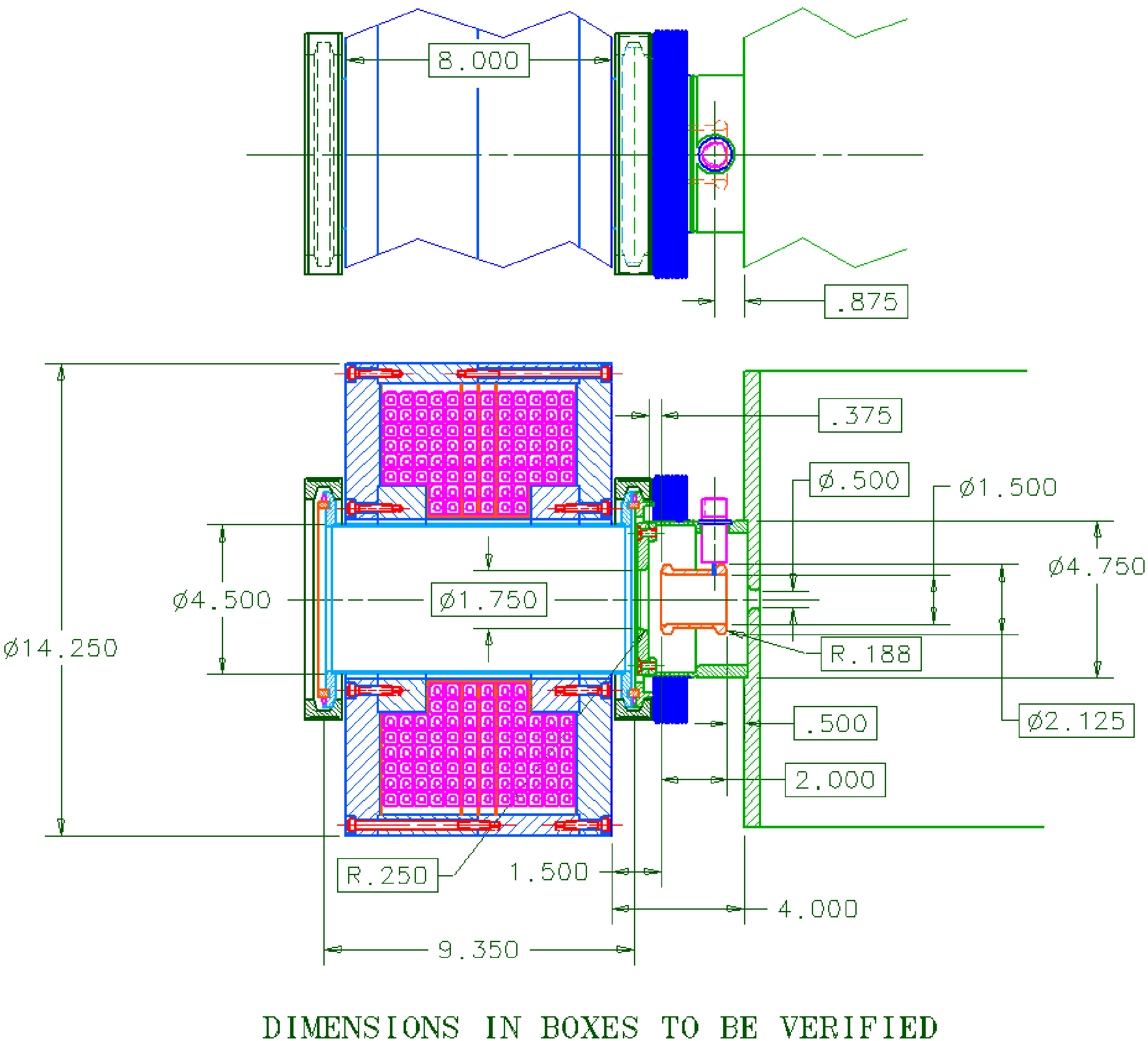


Einzel Lens On at -36.5kV



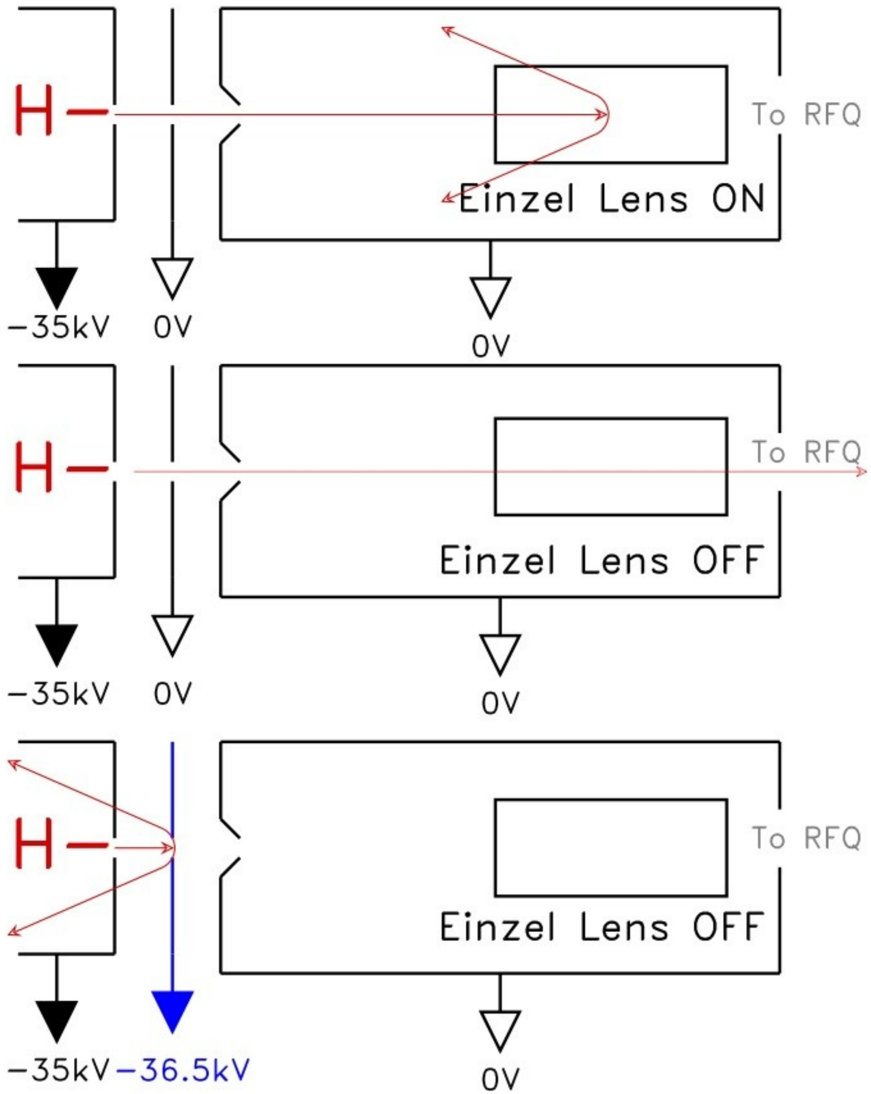
Einzel Lens Off

Possible Realization



Designed by A. Makarov (TD)

Possible Source Pulser (fallback)



Einzel lens is on for ~40μs to deflect beam which is not completely neutralized

Pulser and Einzel lens off for ~60μs

Source is turned off by pulsing an electrode to −36.5kV

FAST HIGH VOLTAGE TRANSISTOR SWITCHES

These MOSFET switches are designed for general high voltage switching applications such as deflection and acceleration grid drivers and electrical test equipment. The switching modules incorporate all features of the well known HTS switch family: Easy handling, high reliability, low jitter and reproducible switching behaviour. The HTS-LC2 series represents the second generation of Behlke low capacitance switches. The HV transient immunity of the HTS-LC2 series has been improved significantly and is now comparable with that of the standard HTS series.

The switch is turned-on by a positive going control signal of 3 to 6 Volts at the control input (pin1). The shielded control cable is terminated by an internal 100 Ohm resistor. The on-time may simply be controlled by the input control pulse width and can range from 200 ns to infinity. The control electronics of the switching module requires an auxiliary supply of +4.75 to +9.0 VDC (pin 3). To ensure a safe off-state of the switch, the auxiliary supply should be permanently present, especially in the case of possible voltage fluctuations or fast transients at the high voltage input.

An interference-proof driver and control circuit provides signal conditioning, auxiliary voltage monitoring, frequency limitation and temperature protection. Any false operating condition (under voltage, over frequency or over temperature) will result in immediate switch deactivation and a TTL compatible fault signal ("L") will be generated at pin 4 of the control plug. All operating conditions (pulse, on, off, fault) are indicated by LED's.

The high frequency burst operation (>10 pulses/100µs) requires the option "HFB" (High Frequency Burst) respectively "I-HFB" (Integrated High Frequency Burst), depending on the number of pulses to be generated. In case of option HFB, external buffer capacitors must be connected to the internal driver circuitry. A continuous high frequency operation above the specified maximum switching frequency requires the option "HFS" (High Frequency Switching). With the help of this option, two external supply voltages can be connected to increase the power capability of the internal switch driver for higher switching frequencies. Those external voltages are +15 V and +380-480 V, depending on switch model. The +5 V auxiliary supply is not required then.

Due to high galvanic isolation, the switches may also simply be operated in floating circuits or in high-side switching applications without any additional isolation transformer or optical coupler. Several housing and cooling options are available to meet individual design requirements. Please refer to product survey **"C3 Variable On-Time, Low Coupling Capacitance, MOSFET"** or consult BEHLKE for more details.

HTS 501-10-LC2 50 kV / 100 A
HTS 701-10-LC2 70 kV / 100 A
HTS 901-10-LC2 90 kV / 100 A

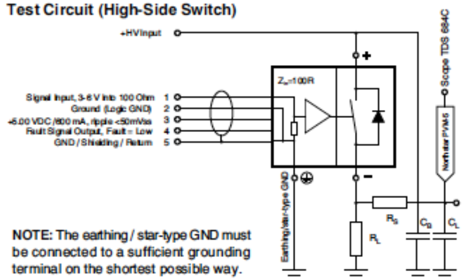
HTS 901-10-LC2 (standard model)

MOSFET TECHNOLOGY

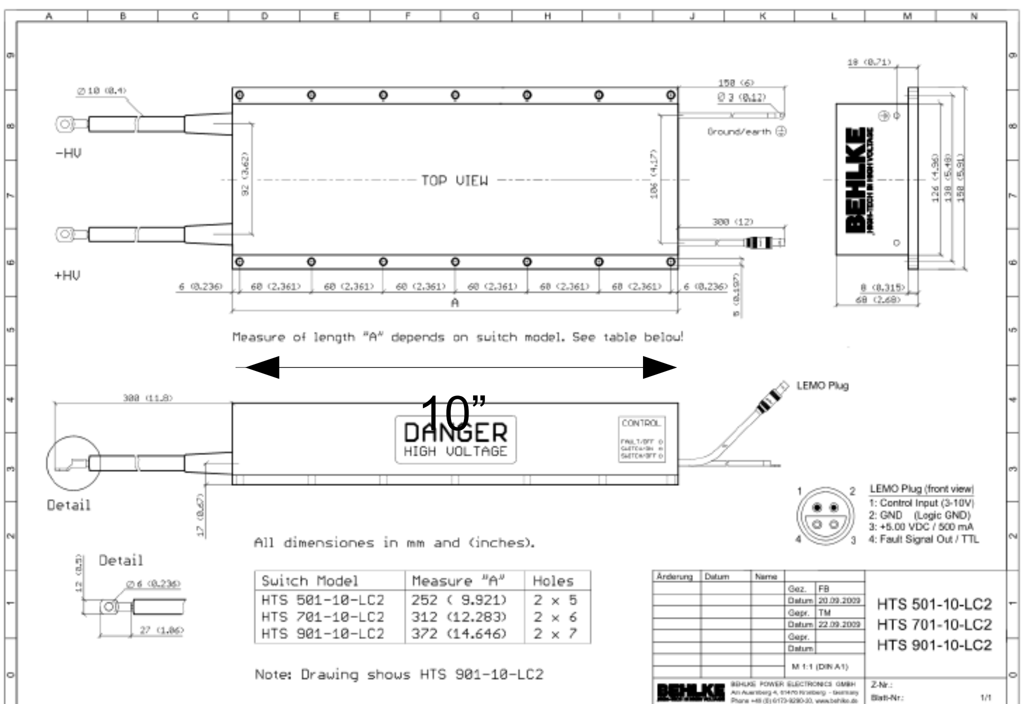
WWW.BEHLKE.DE

Made in Germany

Test Circuit (High-Side Switch)



NOTE: The earthing / star-type GND must be connected to a sufficient grounding terminal on the shortest possible way.

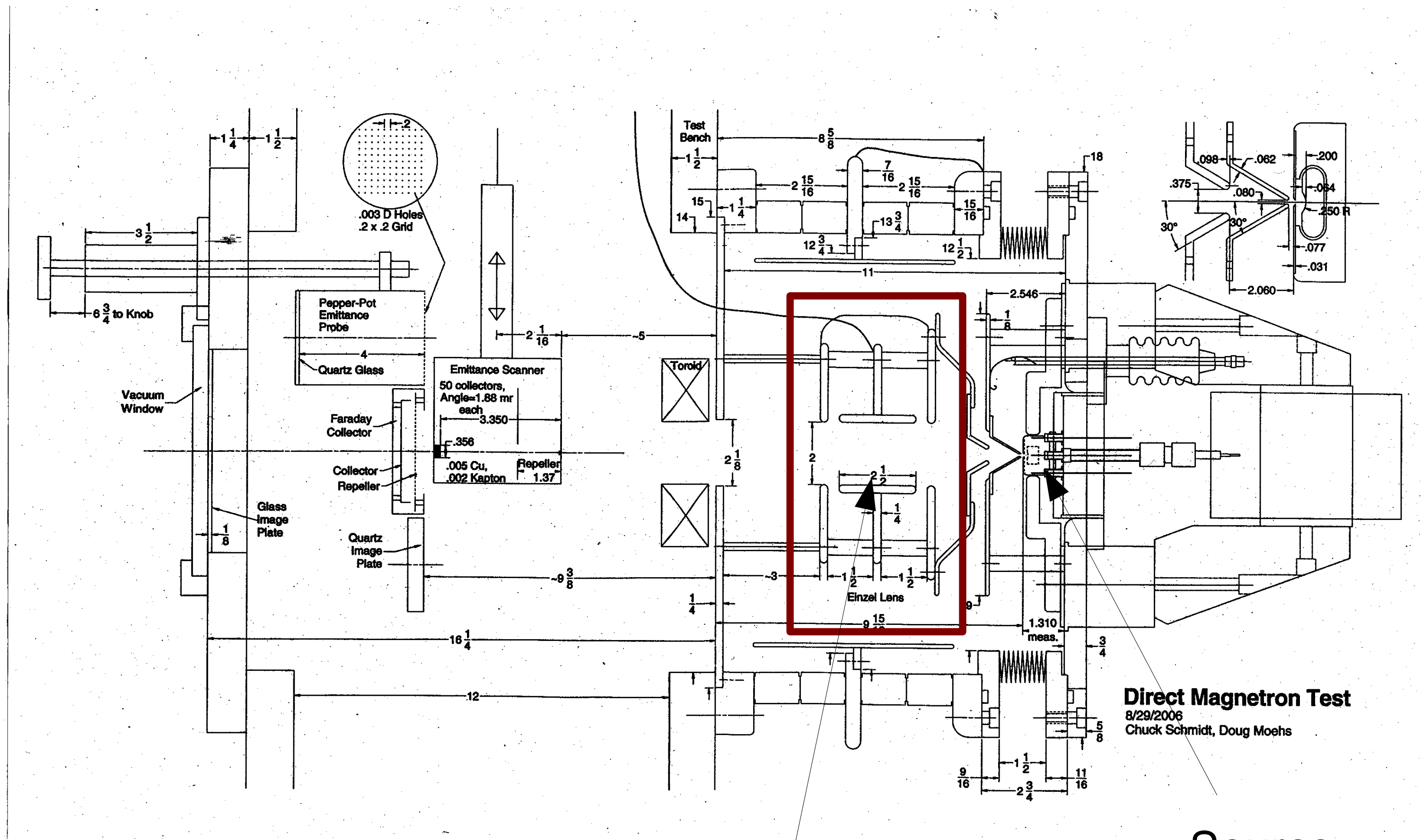


Technical Data

	Specification	Symbol	Condition / Comment		HTS 501-10-LC2	HTS 701-10-LC2	HTS 901-10-LC2	Unit
ABSOLUTE MAXIMUM RATINGS	Maximum Operating Voltage	$V_{O(max)}$	I_{off} < 50 µADC, T_{case} = 70°C		50	70	90	kVDC
	Maximum Isolation Voltage	V_I	Between HV switch and control input / GND		80	100	120	kVDC
	Max. Housing Insulation Voltage	V_{INS}	Between switch and housing surface, 3 minutes			150		kVDC
	Maximum Turn-On Peak Current	$I_{P(max)}$	T_{case} = 25°C	t_p< 200 µs, duty cycle <1%		100		
				t_p< 1 ms, duty cycle <1%		59		
				t_p< 10 ms, duty cycle <1%		36		
				t_p<100 ms, duty cycle <1%		27		ADC
	Maximum Continuous Load Current	I_L	T_{case} = 25°C	Standard model	0.85	0.85	0.85	
			T_{fluid} = 25°C	Option DLC - 1.0 / 1.4 / 1.8 [1]	4.75	4.75	4.75	
				Option DLC - 3.0 / 4.2 / 5.4 [1]	8.25	8.25	8.25	ADC
	Max. Continuous Power Dissipation	$P_{d(max)}$	T_{case} = 25°C	Standard model	32	45	58	
			T_{fluid} = 25°C	Option DLC - 1.0 / 1.4 / 1.8 [1]	1000	1400	1800	
				Option DLC - 3.0 / 4.2 / 5.4 [1]	3000	4200	5400	Watts
	Linear Derating		Above 25°C	Standard model	0.711	45	1.288	
				Option DLC - 1.0 / 1.4 / 1.8 [1]	22.22	31.11	40	
				Option DLC - 3.0 / 4.2 / 5.4 [1]	66.66	93.33	120	W/K
	Operating Temperature Range	T_O				-40...70		°C
	Storage Temperature Range	T_S				-40...90		°C
	Maximum Auxiliary Supply Voltage	$V_{aux(max)}$				9		VDC
ELECTRICAL CHARACTERISTICS	Permissible Operating Voltage Range	V_O			0...50	0...70	0...90	kVDC
	Typical Breakdown Voltage	V_{br}	CAUTION: V_{br} is a test parameter only for quality control purposes and is not applicable in normal operation!	I_{off} >500 µADC	53	74	95	kVDC
	Typical Off-State Current	I_{off}	0.8 x V_O, T_{case} = 25°C			20		µADC
	Typical Static On-Resistance	R_{stat}	T_{case} = 25°C	0.1 x $I_{P(max)}$	20	28	36	
			t_p< 1 µs, duty cycle <1%	1.0 x $I_{P(max)}$	44	62	80	Ohm
	Typical Turn-On Delay Time	$t_{d(on)}$	Resistive load, 0.1 x $I_{P(max)}$, 0.8 x $V_{O(max)}$, 50-50%			250		ns
	Typical Turn-On Rise Time	$t_{r(on)}$	Resistive load, 10-90%	0.1 x $V_{O(max)}$, 0.1 x $I_{P(max)}$	12	14	15	
				0.8 x $V_{O(max)}$, 0.1 x $I_{P(max)}$	32	45	56	
				0.8 x $V_{O(max)}$, 1.0 x $I_{P(max)}$	35	50	62	ns
	Typical Turn-Off Rise Time	t_{off}, t_q	Resistive load, 10-90%	@ $I_{P(max)}$		80		ns
	Maximum On-Time	$t_{on(max)}$				Infinitely		
	Minimum On-Time	$t_{on(min)}$	$t_{on(min)}$ can be customized. Please consult factory.			250		ns
	Maximum Off-Time	$t_{off(max)}$				Infinitely		
	Minimum Off-Time	$t_{off(min)}$	$t_{off(min)}$ can be customized. Please consult factory.			250		ns
	Typical Turn-On Jitter	$t_{j(on)}$	V_{aux} / V_{tr} = 5.00 VDC			3		ns
	Max. Continuous Switching Frequency	$f_{(max)}$	V_{aux} = 5.00 VDC, T_{case} = 25°C, switch will be turned off, if $f_{(max)}$ is exceeded	Standard	1.7	1.2	1	
				Option HFS		100		kHz
	Maximum Burst Frequency	$f_{b(max)}$	CAUTION: Applications with long lasting high frequency bursts may require special cooling measures to prevent overheating of the MOSFET junctions. Please consult factory.			2		MHz
	Maximum Number of Pulses / Burst	N	@ $f_{b(max)}$, Note: Option HFB requires external buffer capacitors (V > 630VDC, C_{ext}≈ 100nF per generated pulse)	Standard		10		
				Option I-HFB		>100		
				Option HFB		>10000		Pulses
	Coupling Capacitance	C_C	HV side against control side		33	46	60	pF
	Natural Capacitance	C_N	Between switch poles		27	20	15	pF
	Auxiliary Supply Voltage Range	V_{aux}	5.00 VDC recommended for best driver efficiency			4.75 – 9.00		VDC
	Intrinsic Diode Forward Voltage	V_F	T_{case} = 25°C, I_F =10 A		40	57	74	VDC
	Diode Reverse Recovery Time	t_{rrc}	CAUTION: Intrinsic diodes must not be used in normal operation. Inductive load requires fast free-wheeling diodes (FDA) in parallel to the switch!	I_F =10A		<250		ns
	Auxiliary Supply Current	I_{aux}	V_{aux} = 5.00 VDC, T_{case} = 25°C	0.1 x $f_{(max)}$	250	350	450	
				@ $f_{(max)}$	800	800	800	mADC
	Control Voltage Range	V_{tr}	>5 VDC recommended for best EMC			3 - 10		VDC
NS	Dimensions		Standard housing, without pigtails		252 x 150 x 68	312 x 150 x 68	372 x 150 x 68	mm³
	Weight		Standard housing		3200	4000	4700	g

Rise time 45ns

H- Source Test Stand



Source

Einzel Lens,
Already at
38kV

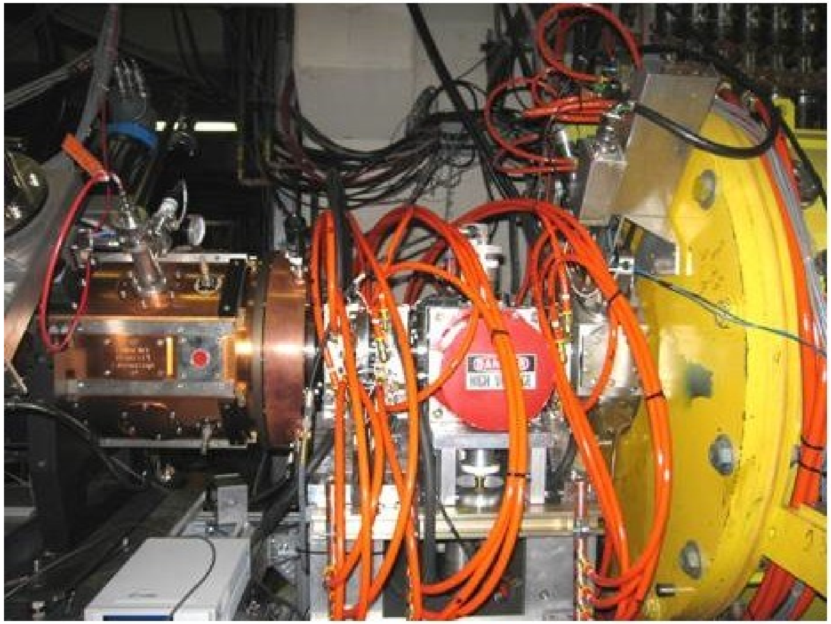
RFQ

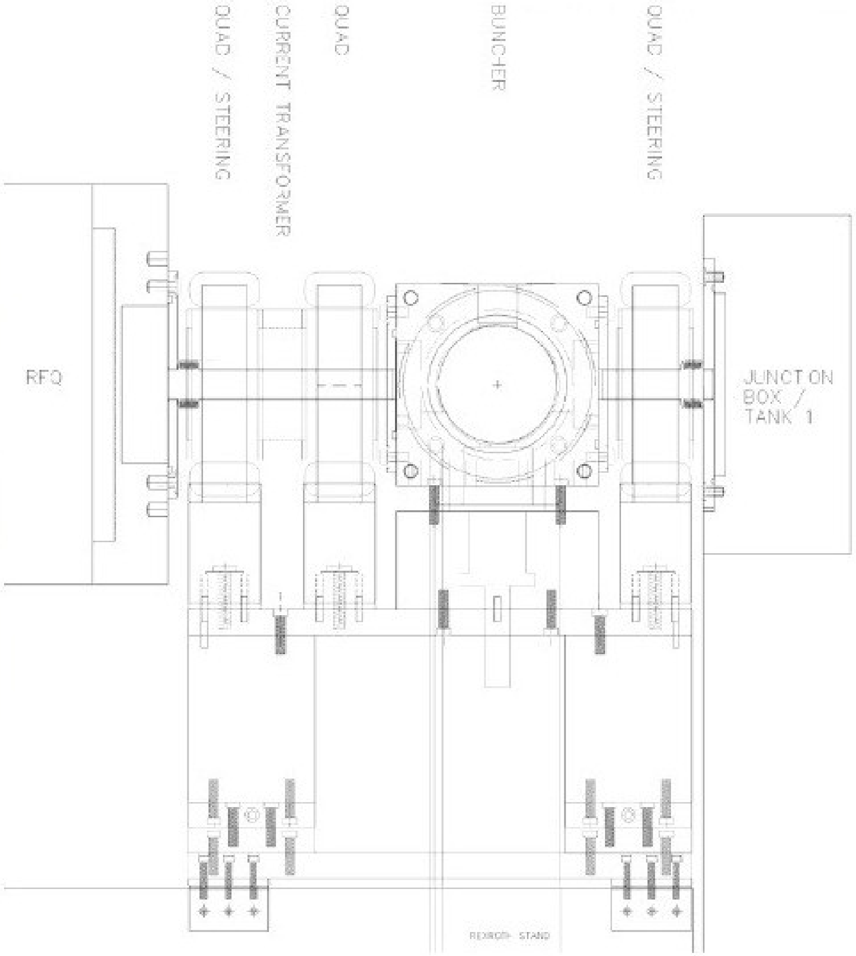
Some RFQ Params

- Input energy: 35keV H-
- Output energy: 750keV
- Frequency: 200MHz
- Input current < 60mA
- > 97% capture efficiency
- 1.2 to 1.6m long
- ~100kW pulsed.

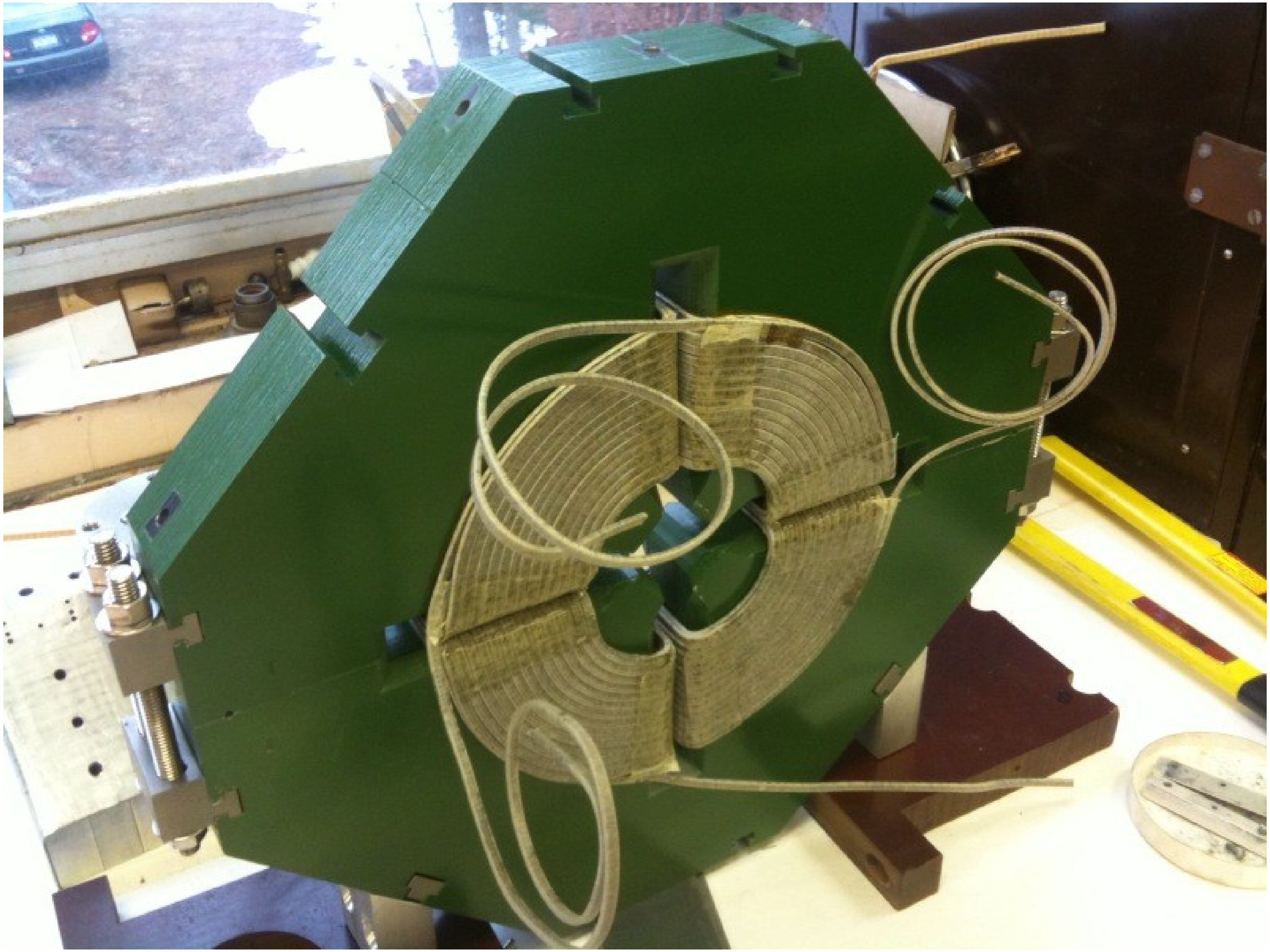
MEBT

MEBT will be a copy of BNL's MEBT





New BNL Quad



65 T/m at 300A.
4.5 cm long.

Requirement is 45 T/m

What needs to be done?

Work

- Show that round source can produce > 90mA at 100us pulse length.
  - Check reliability claims
- Finish testing chopper at 36kV pulsed.
  - Design and build 36kV chopper power supply, PFN.
  - Can Einzel lens be the ONLY chopper?
- Power supply for RFQ, Buncher, Quads and Solenoids.
- Instrumentation
  - Wires, toroids.
- Test stand for RFQ for validation tests
  - Borrow instrumentation from HINS? Get Vic Scarpine involved.

Complete installation in 2011-2012 shutdown!!!!